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IDENTIFYING WEATHER SUITABLE FOR PRESCRIBED BURNING[1]

William R. Beaufait and William C. Fischer[2]

ABSTRACT

Fire managers require 24-hour records of temperature, relative humidity, and windspeed to use fire efficiently and effectively. When carefully calibrated and interpreted, modified hygrothermographs provide minimum instrumentation to obtain these records. An actual case of record interpretation and use is included.

Prescribed fire is being used as a management tool on an increasing acreage each year. Burns are being scheduled during dry seasons when danger of escape requires careful assessment of fire weather. Furthermore, growing concern for management of atmospheric resources will dictate scheduling of fire treatments to coincide with weather that minimizes the amount of airborne particulates and reduces smoke in valley bottoms.

The Society of American Foresters (1958) defines prescribed burning as the "Skillful application of fire to natural fuels under conditions of weather, fuel moisture, soil moisture . . . required to accomplish certain planned benefits . . . ." Both fuel and soil moisture are dependent upon recent weather history. Prescribed fire planning, therefore, must be based on a complete record of current weather.

Standard fire-weather observations are typically made in the afternoon. This practice ignores diurnal variation in relative humidity and temperature. Windspeed, of critical importance to a fire's spread, is rarely observed for more than a few minutes at one time during the afternoon. Obviously, gaps in local weather intelligence hide many opportunities for conducting prescribed fires.

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[1]The Northern Region and the Intermountain Forest and Range Experiment Station are jointly supporting a series of studies of prescribed fire and their forest management applications. Groups of scientists are investigating the effects of a wide range of fire intensities and their impacts on timber regeneration, watershed values, wildlife habitat, and atmospheric resources. This publication is the first of a series reporting the results of these efforts.

[2]Respectively, Principal Research Forester and Research Forester stationed at the Northern Forest Fire Laboratory, Missoula, Montana.

Variation due to change in elevation must also be identified in mountainous terrain. In certain situations, elevation differences can be even more important than diurnal changes in temperature and relative humidity.

Fire managers have teamed with Weather Bureau and private meteorologists to produce and use forecasts geared to the special needs of fire use. The forecaster performs his best service when he can advise the fire manager how tomorrow's weather will be different from today's. Forecasters require more information than provided by standard fire-weather observations because prescribed fires are scheduled to take advantage of any burning period appropriate to burning objectives.

Fire managers must also assess potential fire behavior as it may change with topography and available fuels. For example, a burning unit may be shielded from normal surface winds but subject to local thermal air movement that varies greatly with time of day. Such intimate knowledge of local weather can be gained only through 24-hour records of wind, temperature, and relative humidity specific to the area under study.

Continuous weather records can be obtained without expensive or cumbersome recording equipment. Hygrothermographs are easily modified to provide records adequate to prescribed burning needs. Fischer et al. (1969) have added a wind-recording arm to a hygrothermograph (fig. 1) to obtain data on diurnal wind patterns as an aid in scheduling prescribed fires.

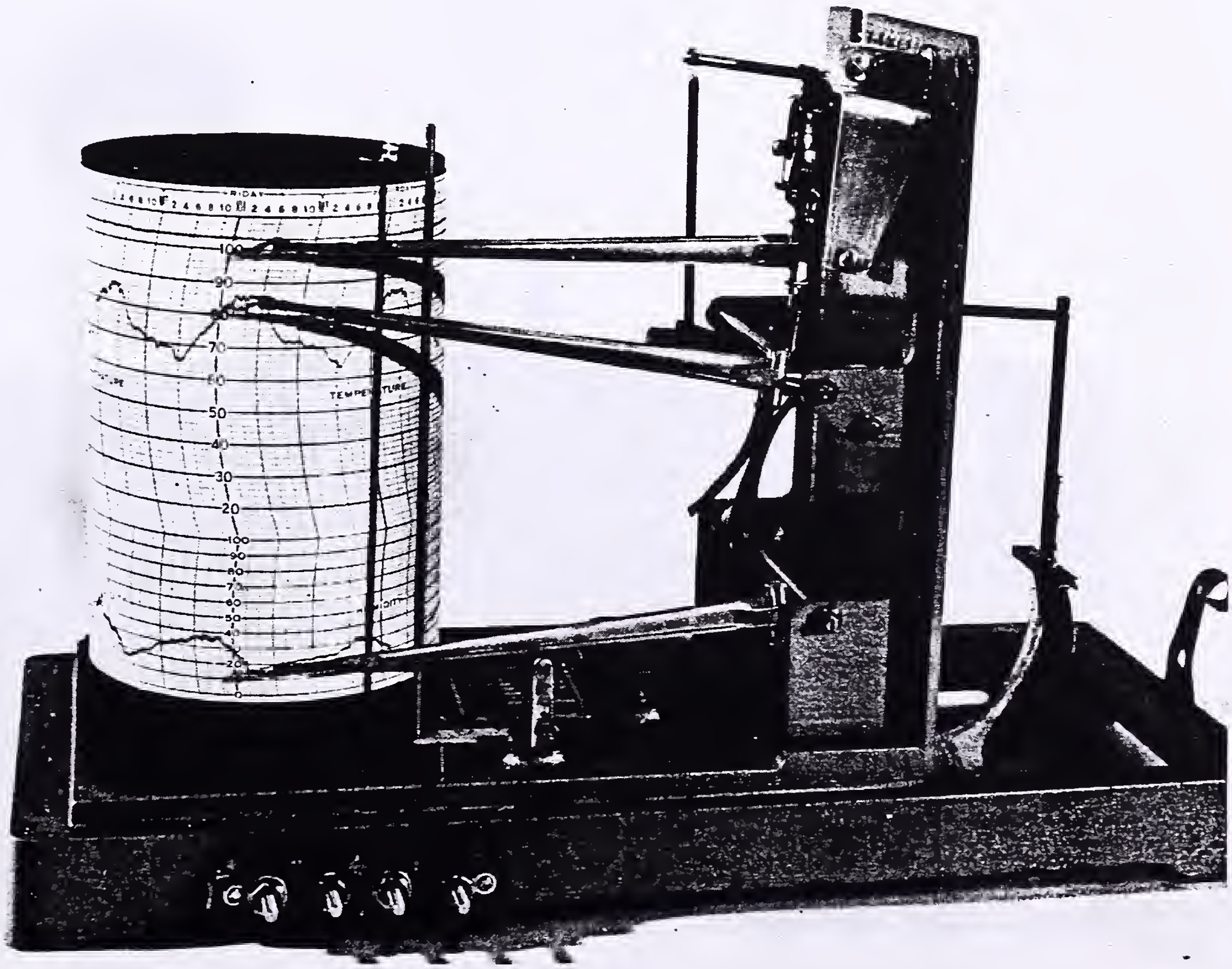

Figure 1.--A hygrothermoaerograph (HTAG). The upper arm records wind movement as transmitted from a contacting, totalizing-type anemometer.

USING CONTINUOUS WEATHER RECORDS

The following examples are taken from a large-scale study of prescribed fire effects in northwestern Montana. They illustrate burning conditions typical in mountainous terrain.

Prescribed burning decisions are frequently based solely on weather records from valley bottom stations which are common at many administrative sites. We installed both a standard valley bottom station and another station at the elevation of our burning sites (fig. 2). Figure 3 is a comparison of actual hygrothermograph records from these two stations: Stillwater Bench (3,200 feet) and a higher site on the upper third of the adjacent slope of Keith Mountain (4,500 feet).

Close inspection of the lower chart in figure 3 reveals typical diurnal fluctuation in temperature and relative humidity at the 3,200-foot site. A similar trend is discernible at the 4,500-foot site, but without both temperature and relative humidity extremes. The nighttime temperature and relative humidity values at Stillwater Bench indicate the presence of a typical nocturnal inversion in the valley. During the night, temperatures are higher and relative humidities are lower at Keith Mountain than at Stillwater Bench. The position on the slope of the Keith Mountain station has placed it above the cool, moist air of the valley. For an explanation of inversion-causing phenomena see Cramer (1961).

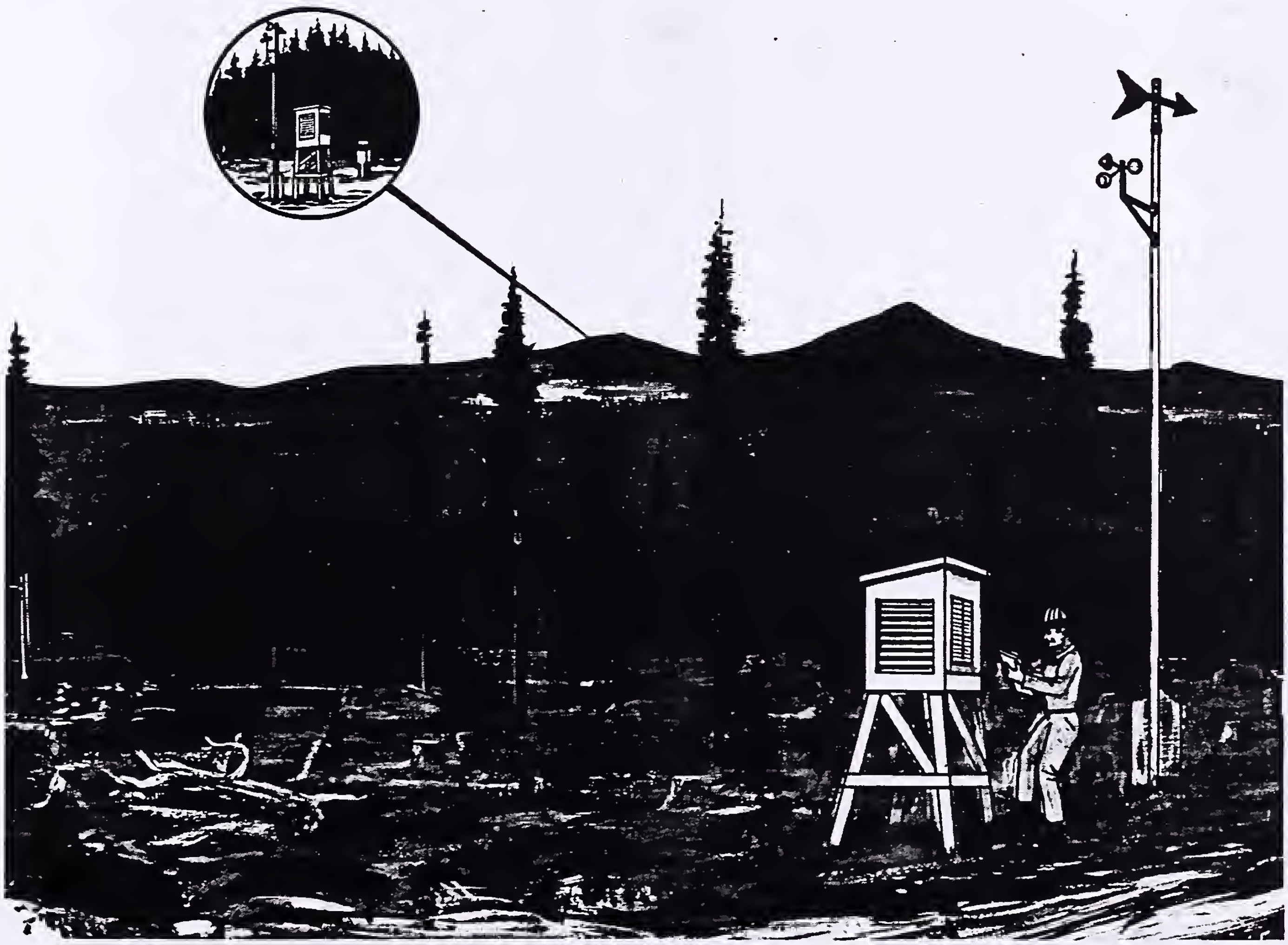

Figure 2.--Relative location of Stillwater Bench (foreground) and Keith Mountain (upper slope) weather stations.

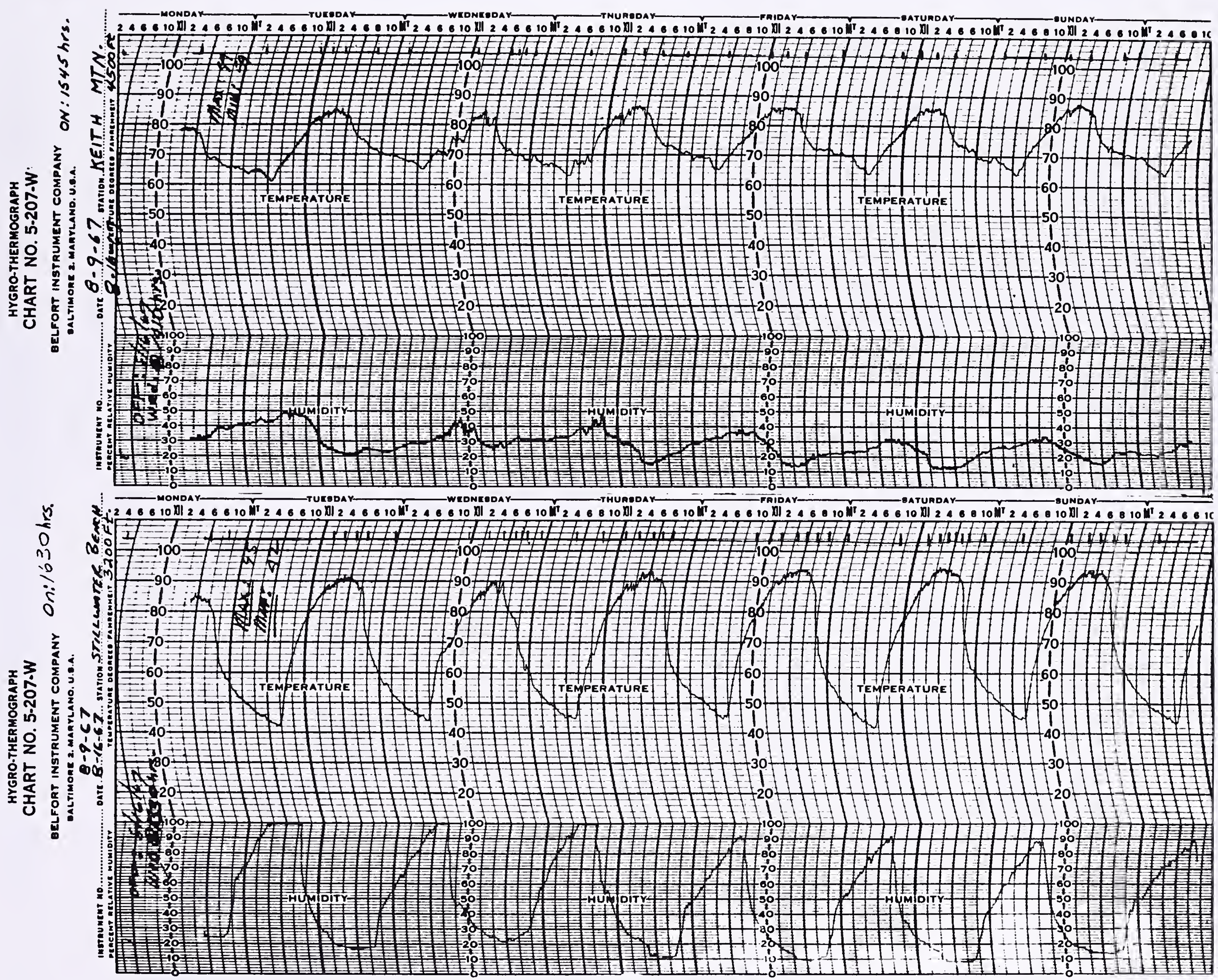

Figure 3.--HTAG charts from fire-weather stations at 4,500 feet (upper chart) and 3,200 feet (lower chart) at Miller Creek Block, August 8-15, 1967.

The effect of the difference between conditions at the two stations can be shown in terms of National Fire-Danger Rating System Fine Fuel Moisture. Figure 4 compares Fine Fuel Moisture values for Stillwater Bench and Keith Mountain at hourly intervals. Since values were calculated from the temperature and relative humidity records shown in figure 3, the trends they show are very similar to those on the hygrothermograph records.

For the days represented in the charts, 1600-hour Fine Fuel Moisture and relative humidity values were compared with 24-hour averages of fine fuel moisture and relative humidity. Two different pictures of fire-weather conditions emerged, as shown in table 1. According to the 1600-hour records of fine fuel moisture and relative humidity, more severe fire weather was recorded at the lower elevation station on Stillwater Bench than at Keith Mountain. The 24-hour averages, however, contradict this assumption. We feel that the 24-hour records more realistically characterize the effects of local weather on fuel moisture than do the once-per-day observations.

Burning objectives and air quality considerations should determine the windspeed permitted during treatment. Our prescription required windspeeds be less than 5 m.p.h. For the period represented in figure 3, wind usually ceased at about 2000 hours. Had the temperature and relative humidity conditions been favorable, ignition would be planned for this hour. In this instance, burning plans were canceled.

Continuous, onsite weather records contributed significantly to burning success. Actual weather conditions on the study area could easily have been misjudged if: (1) valley bottom fire-weather station data alone had been used, or (2) once-daily observations had been relied upon to characterize the entire 24-hour period.

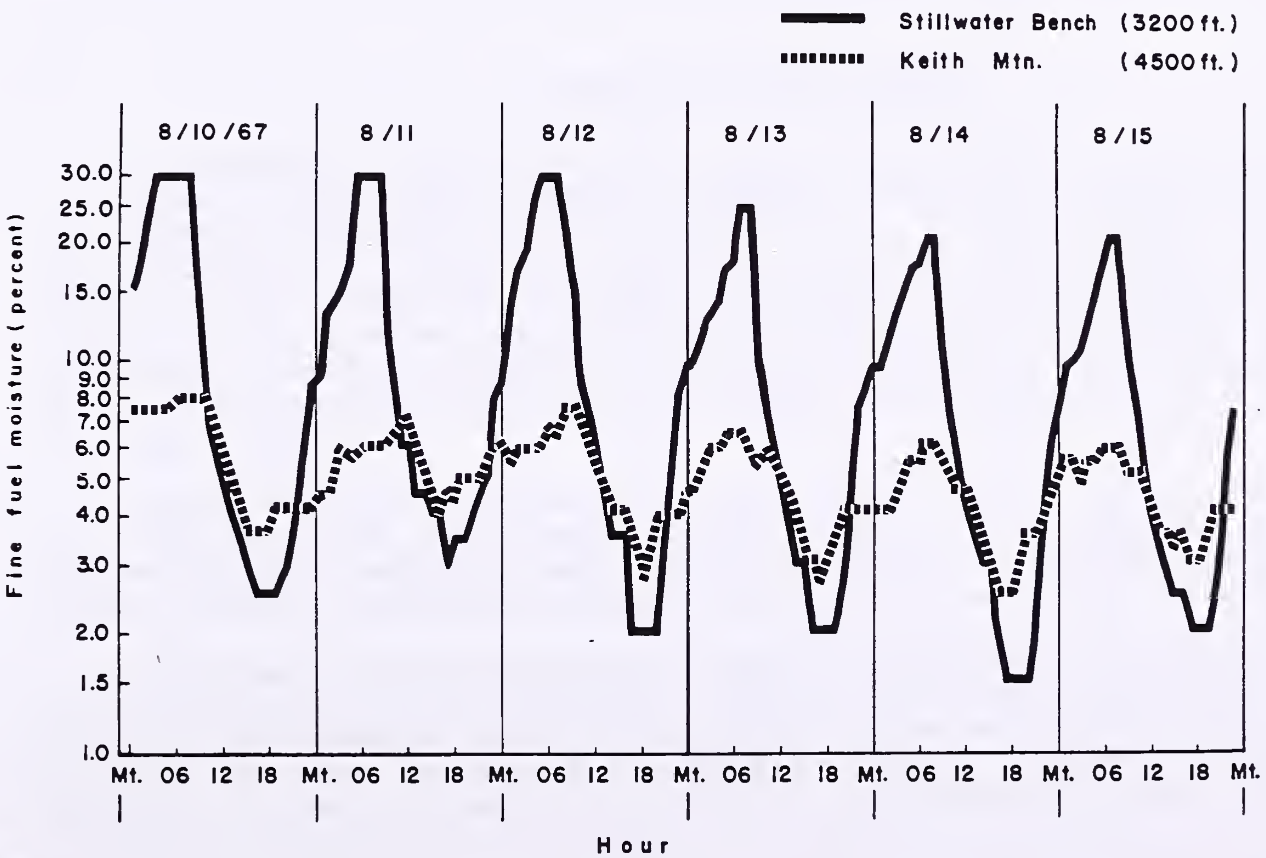

Figure 4.--National Fire-Danger Rating System Fine Fuel Moisture computed at hourly intervals for Stillwater Bench and Keith Mountain stations.

Table 1.--Fine Fuel Moisture and relative humidity--recorded and calculated averages for Stillwater Bench (3,200 feet) and Keith Mountain (4,500 feet), 1967

Date	1600-hour Fine Fuel Moisture	1600-hour relative humidity	24-hour average Fine Fuel Moisture	24-hour average relative humidity
	Percent	Percent	Percent	Percent
		STILLWATER BENCH		
August 10	2.0	18	13.3	52
11	4.0	25	11.0	50
12	2.0	20	11.6	54
13	2.0	13	8.6	42
14	1.5	10	7.7	40
15	2.5	15	8.4	38
6-day mean	2.3	16.8	10.1	46
		KEITH MOUNTAIN		
August 10	3.5	22	6.4	42
11	4.0	24	4.8	40
12	3.5	16	5.5	34
13	2.5	14	4.5	27
14	2.5	13	4.2	22
15	3.0	18	4.3	24
6-day mean	3.2	17.8	5.0	30

IMPORTANCE OF THE EXAMPLE

The combination of meteorological events presented above is not unique in mountainous terrain. Hayes (1942) described a frequent "inversion of fire behavior . . . with most dangerous conditions in the thermal belt . . . ." Barrows (1951) stressed the importance of Hayes' findings when evaluating nighttime fire behavior in the northern Rocky Mountains. Similarly, in Canada, both MacLeod (1948) and MacHattie (1966) stressed the correlation between low maximum night relative humidities and low fuel moistures. MacLeod also observed, "In the absence of rain, relative humidity is the only nocturnal weather factor which has a significant effect on forest fuel moisture in standing timber."

Gwinner (1965), in his study of fire danger as related to airmass in the Ouachita Mountains of Arkansas and Oklahoma, concluded that ". . . in polar air, 24-hour burning conditions are definitely more severe on ridgetops than in valley bottoms even though afternoon fire-danger ratings differ little between the two locations."

This example has provided three lessons for prescribed fire planning: (1) Temperature inversions can create weather conditions on a burning site quite unlike those at valley bottom weather stations; (2) 24-hour records may reflect drying conditions different from those logged at midafternoon observations alone; and (3) diurnal wind patterns, if known, can provide opportunities for burning which might otherwise be ignored.

Fire managers will need to use all weather data available to aid in making intelligent burning decisions. Hygrothermograph records, judiciously interpreted, can make their tasks a bit lighter.

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